Work Enclosures for Toxic and Radioactive Materials*

Introduction

To handle radioactive and toxic materials safely, it is often necessary to enclose either the operating personnel or the hazard. Enclosing the hazard allows personnel to work under nearly normal conditions and prevents hazardous material from spreading to other areas of the Laboratory.

The Hazards Control Department develops design guidelines for these enclosures (see also Supplement 33.42 of this manual). Because enclosures are designed to be safe for specific operations, Hazards Control shall always be consulted when any intended use does not fall within the original design parameters.

Selection of Enclosures

The decision as to what enclosure to use for a particular operation must always be based on the relative hazard of the material and experimental procedure to be used. Specifically, the selection must be based on how well the enclosure

- Controls the spread of the hazardous material in the event of an accident;
- Protects the experimenter and other personnel from the hazardous material;
- Allows access to its interior without contaminating the outside area;
- Contains an inert atmosphere if required for the experiment; and
- Handles overpressures and fires that might occur in the enclosure.

Work enclosures for toxic and radioactive materials are either hoods or glove boxes. The ventilation fans serving hood enclosures control the direction of air flow away from the experimenter into an exhaust system. A glove box completely encloses the hazardous material and is generally used for high toxicity or radioactive material.

The exhaust air from a hood enclosure may have to be filtered before being released to the atmosphere. Contact the Environmental Protection Department to evaluate the effluent's impact on the environment and necessity for permits when selecting and designing ventilation systems. Even occasional use of radionuclides in a hood may require high-efficiency filtration of the stack effluent. Any decision to use a glove box for solid toxic or radioactive materials automatically requires that the effluent from the glove-box ventilation system be filtered. If air filters are installed, a log of pressure readings from installed gages must be maintained by the user. A Hazards Control evaluation will determine filtration requirements if only gases or vapors are present. Supplements 12.01 and 12.05 contain further information on exhaust system effluents and high-efficiency particulate air (HEPA) filters.

Hoods

Hoods usually are used for operations of low relative hazard. They are ventilated enclosures with one open side. The chemistry lab "fume" hood is the most common example. The ventilation system directs the flow of air away from the user and carries aerosols and gases into the exhaust system. The open side is generally constructed with an adjustable transparent window sash that, when open, provides a large access area for equipment installation. When the hood is in use, the window can be partially closed to ensure adequate air velocity through the opening. Users must always verify that the hood is working properly, i.e., the Hazards Control velocity check is current, the fan is operating, air flow indicators are functioning. Users must also request a reevaluation of performance when making changes in the set-up of experimental apparatus.

Air Flow

When the hood is in use, the air velocity through any part of the face opening must average 125 ft / min, with individual readings of ±25 ft / min

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(10–150 ft / min), to ensure that room air currents do not overcome the direction of air flow. Other air-velocity specifications may be recommended depending on favorable or unfavorable conditions that exist for the makeup air supply. Ideally, air velocities should be uniform (within 10 percent) in all areas of the hood face. Excessive flow (e.g., above 200 ft / min) will sometimes cause eddies that can drag contaminants out of the enclosure.

It is necessary to adjust the opening size from time to time to maintain the proper air flow so as to compensate for change in the balance of the air-conditioning system or due to increasing pressure drop across the filters as they become dust-laden. Hazards Control frequently measures air flow through the hood opening and adjusts the opening size to obtain the required air flow.

Equipment shall not be placed too close to the opening of a hood. Such an obstruction may cause turbulences that could affect the desired air-flow pattern into the hood. Smoke testing indicates when hoods are working properly (i.e., turbulence in the corners is not causing reverse flow, drag out, or incomplete capture). This test is performed by the area health and safety technician quarterly and before new experimental setups are put in use.

Air-flow gauges for continuous monitoring must be installed on ventilation systems that exhaust highly hazardous materials (e.g., radioactive materials, carcinogens, and pathogens) or where the nature of the operation would present unacceptable hazards if the system malfunctioned. These gauges shall be installed in a location where the operator can readily observe the system's performance. These devices can be pressure gauges across a sharp edge in the ducting or velocity sensors in the hood's face. Further details on air-flow monitoring are available in *Industrial Ventilation* (Sec. 9) and from the Industrial Hygiene Laboratories Group of Hazards Control (ext. 2-5198).

Housekeeping

Unused equipment or equipment that will not be used in the immediate future shall be removed from the hood. Hoods shall not be used for long-term storage of material and equipment merely as a matter of convenience. An unnecessarily cluttered hood is inefficient from the standpoint of manipulating equipment and can cause turbulent air flow in the hood. Stored equipment may become contaminated or may contaminate a current experiment, causing an unnecessary decontamination or disposal problem.

Any equipment or material removed from a hood shall be carefully inspected for contamination. Hazardous materials in a hood must be clearly labeled so that all users of a hood are aware of their presence. The manner of use of electrical apparatus and plug strips shall be carefully evaluated by members of the area Hazards Control Safety Team before being used with flammable or corrosive materials because they can be spark sources that could cause fire or explosion, and repeated exposure to corrosives will lead to damage, thereby increasing the hazard of electrical shock.

Interior Configuration

Hoods shall be well lighted, and interior surfaces should be smooth and impermeable. Corners shall be rounded and free from cracks and crevices to provide for easy cleaning in the event of an accident. Where practical, the hood floor shall be protected by an easily disposable plastic sheet covered with a layer of absorbent material.

Unusual Operations

All operations of an unusual nature (for example, using perchloric acid or generating explosive concentrations of materials) shall be carefully evaluated before the decision is made to use a hood as a workplace. Hoods provide only limited protection. The Hazards Control Safety Team shall be consulted when the characteristics or behavioral patterns of material to be used in a hood are not thoroughly known to the experimenter.

Fire Protection

Fire protection / suppression features will be required for some installations, as dictated by DOE Orders. The materials of construction and flammability levels of vapors must be evaluated. Consult the Fire Protection Engineering Group (ext. 3-2431) of Hazards Control for specific guidance.

Glove Boxes

Glove boxes are used for handling high-hazard materials or when an inert atmosphere is required to control oxidation or fire. The pressure inside a glove box is kept negative with respect to room pressure so that any leakage or noncatastrophic failure of the enclosure will result in a substantial inflow of air through the opening into the glove box. For certain operations positive pressure boxes are designed to prevent intrusion of

moisture or external contamination. Such boxes are not intended for highly hazardous operations and must be carefully evaluated for appropriateness. These installations must be readily identified and administratively controlled to prevent misuse.

Air Flow

The following questions must be considered when calculating air-flow requirements for glove boxes:

- What is the area of the opening into a box if a glove is accidentally pulled off?
- What is the area of the largest opening into a box if a door is opened or a bagout cover is accidentally torn off?
- Will the process use or generate an explosive or flammable concentration of volatile solvents or organic materials?

In determining the area of a realistic accidental or operational opening into a glove box, the operations taking place within the box during planned or accidental breaches must be considered.

When small accidental breaches could release hazardous materials into the workplace, an inward air flow of 150 ft/min shall be used as a design criterion. This criterion shall also be used for operational openings; however, the Hazards Control Safety Team may agree to lower values depending on the situation. If large catastrophic failures are credible (e.g., loss of a window) a detailed safety analysis is necessary to determine air flow and ventilation system requirements.

A hazard evaluation must be made by the area Safety Team before flammable materials are used in a glove box. As a rule, these materials shall be avoided or the quantities kept to minimum practical amounts.

Exhaust air from glove boxes containing toxic or radioactive material that may generate airborne particulates shall be filtered by a HEPA filter. A second filter, in series, shall be used for radioactive materials. Filters that can handle the maximum required air flow must be chosen.

Failures

Because glove-box failures usually occur at the glove ports, these ports should be capped when not in use. The flexing of gloves, deterioration from corrosive chemicals, and radiation in the box reduce normal glove life. Experience based on previous glove failures usually dictates the useful safe life of gloves. It is mandatory, therefore, that a well-planned inspection and replacement schedule be observed.

A HEPA filter may be required in the supplied-air port to the box to prevent loss of material from the inside of the box to the room.

Vacuum Gauges

Glove boxes shall be equipped with vacuum gauges that indicate the box is under negative pressure. Before a box is used, this gauge shall be checked to ensure the box is in safe operating condition. If an inert gas environment is required in the box, care shall be exercised during all purging operations to ensure that the internal pressure in the box is maintained negative to room pressure. An air-flow gauge (sharp-edged orifice) shall be installed to indicate whether exhaust is adequate for the box design and its current use.

Ports

Material is introduced or removed through airtight ports. These ports may be double-doored air locks in smaller glove boxes or large bag-covered ports in larger glove boxes. These ports shall be designed to prevent the loss of negative pressure within the box while the port is in use. Pass-in / out ports shall be monitored for contamination after each use.

Lighting

Glove boxes shall be well lighted from the outside. “Shadowless” illumination, like that provided by fluorescent tubes, is generally suitable.

Other Considerations

Emergency Power

Emergency power to exhaust fans is required for high-hazard operations to assure nonstop performance of the exhaust and containment systems. Provisions for such backup power is also recommended for other systems if a failure analysis or design basis accident evaluation reveals the potential for on-site or off-site harm.

Not every situation requiring emergency power is described in DOE Order 6330.1A. Thus, criteria will be developed on a case-by-case basis by joint interaction of the program, Hazards Control, and Plant Engineering.

Seismic Safety

Hoods, glove boxes, and enclosures shall meet the seismic restraint standards developed by Plant Engineering.

Environmental Issues

National Environmental Policy Act (NEPA) documentation and air permit application may be required. New operations and changes to existing configurations must be evaluated by an environmental analyst.

Bibliography

DOE Order 6430.1A, "General Design Criteria," U.S. Department of Energy, Washington, DC (April 6, 1989).

Industrial Ventilation, A Manual of Recommended Practice (American Conference of Governmental Industrial Hygienists, Cincinnati, OH, latest edition).

ASHRAE Handbook. 1989 Fundamentals (American Society of Heating, Refrigeration, and Air-Conditioning Engineers, Inc., Atlanta, GA, 1989).